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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 June 2001 (07.06.2001)

PCT

(10) International Publication Number
WO 01/41511 A1

(51) International Patent Classification[7]: H05B 33/00, 33/26

(21) International Application Number: PCT/NL00/00895

(22) International Filing Date: 4 December 2000 (04.12.2000)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1013742 3 December 1999 (03.12.1999) NL

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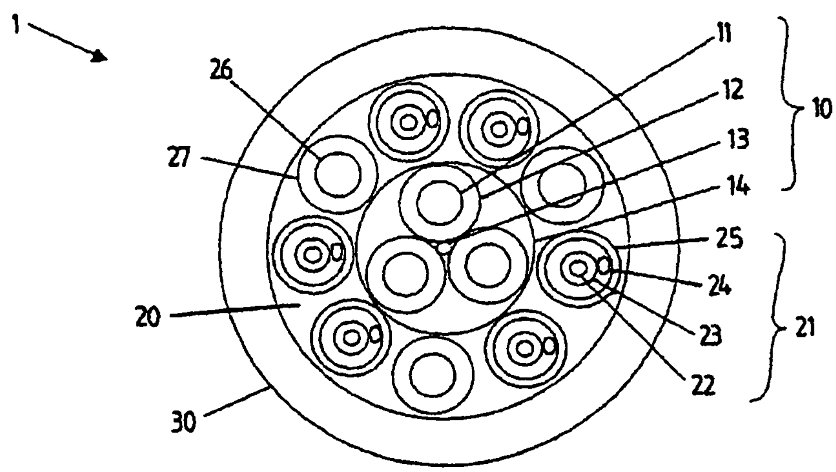
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SYSTEM FOR GENERATING LIGHT BY MEANS OF ELECTROLUMINESCENCE



(57) Abstract: An EL light wire (221) according to the present invention comprises a core electrode wire (22); a layer with an EL substance (23) provided around said core electrode wire; and an extruded protective layer (225) of a transparent, electrically conducting polymer preferably containing a photoluminescent phosphor, which protective layer acts as outer electrode and is extruded under vacuum conditions around the combination of core electrode wire (22) and EL layer (23). A composite EL light wire (301) according to the present invention comprises an EL assembly (302), comprising two core electrode wires (22_1, 22_2) extending substantially parallel to each other, each provided with a layer with an EL substance (23_1, 23_2) arranged around said core electrode wire, and also a protective layer (304) of a transparent, electrically conducting polymer preferably containing a photoluminescent phosphor, extruded around the EL assembly (302) under vacuum conditions.

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Title: System for generating light by means of electroluminescence

The present invention relates in general to a system for generating light by means of electroluminescence.

More particularly, the present invention relates to an electroluminescence light source of the line type or wire type, which is hereinafter also indicated as a linear light source, which means that a length measurement of the light source is considerably longer than its transverse measurements.

The generation of light on the basis of electroluminescence is known per se. Electroluminescence is a property of some materials whereby they transmit light if they are subjected to an electric field. Since electroluminescence (hereinafter abbreviated to EL) is a phenomenon which is known per se, it will not be explained further.

An EL light source in general comprises at least three parts: a substance with said electroluminescence property, and two electrodes which create an electric field at the location of this substance when an electric voltage is connected to them. A linear embodiment of such an EL light source will hereinafter also be indicated by the term primary EL light wire.

An example of such a primary EL light wire is described in British Patent Application GB-2.273.606. This publication shows that a primary EL light wire can be configured in different ways. For example, the two electrodes can be intertwined wires (figure 1 of that publication).. It is also possible for the two electrodes to be a combination of a conducting central core and a wire wound around it (figure 3 of that publication). It is also possible that an inner electrode is arranged inside a tubular outer electrode of a transparent conducting material (figure 5 of that publication).

The publication also shows that said three components are enclosed in a transparent plastic casing, which, however, is not

essential for proper functioning of the primary EL light wire in the electroluminescent respect.

In the electrical respect, EL light sources have a capacitive behaviour. This offers the advantage that they can be supplied with power in a relatively energy-saving way by making use of an alternating voltage supply, wherein the output stage forms a tuned oscillation circuit that is in resonance. The capacitive EL light source here is an electrical component of the tuned circuit.

However, a problem here is that the impedance of an EL light source is dependent, inter alia, upon its length. It is further desirable for the EL light wire to provide a good light output along its entire length.

In practice, this has led to primary EL light wires being supplied in fixed, predetermined lengths with matching power supply, the output stage always being tuned to the capacity value of a light source of a certain length. An important disadvantage of this is that a power supply that has to be connected to the light wire must always be provided. This is in particular a disadvantage if several linear light sources have to be placed one after the other.

An important object of the present invention is to provide an improved linear EL light source.

In particular, it is an object of the present invention to provide a linear EL light source with an increased light output per unit length.

In particular, it is also an object of the present invention to provide a linear EL light source whose length can be freely selected with a great degree of flexibility, making use of the same power supply unit. More particularly, there is a need for a construction for a linear EL light source which will still be provided in units or segments of a predetermined length, but in the case of which several units can be coupled to each other in order to produce a linear light source of a greater length, and in the case of which a subsequent unit can be electrically and mechanically coupled to a previous unit and can receive its power supply via said previous unit.

It is further an object of the present invention to provide a linear EL light source that is suitable for relatively high powers.

EL light sources known so far further have the drawback that there is only a limited choice for the colour of the generated light. The present invention also aims to overcome this drawback.

A typical application area of EL light sources is the marking of paths and/or roads. One may also think of aisle lighting in aircraft or the like. From the point of view of safety considerations, it is then a drawback of the EL light sources known until now that they no longer generate light in the case of a failure of the power supply. The present invention also aims to overcome this drawback.

According to an important aspect of the present invention, a linear EL light source comprises a collection of several primary EL light wires, which are accommodated in a common transparent casing. The EL light wires are arranged around a core, which can also serve as current conductor.

According to a further aspect of the present invention, primary EL light sources are grouped into units of two functionally interacting light wires, the two cores of the two light wires serving for supply.

These and other aspects, features and advantages of the present invention will be explained in greater detail by the following description of a preferred embodiment of an EL light source according to the invention with reference to the drawing, in which the same reference numerals indicate the same or comparable components, and in which:
figure 1 shows a diagrammatic cross section of a linear EL light source according to the present invention;
figure 2 illustrates diagrammatically an electrical connection possibility of a linear EL light source according to the present invention;

figure 2B illustrates diagrammatically another electrical connection possibility of a linear EL light source according to the present invention;
figure 3 shows diagrammatically a cross section of a known primary EL light wire;
figures 4A-B illustrate diagrammatically embodiments of a primary EL light wire according to the present invention;
figures 5A-C illustrate diagrammatically embodiments of a composite EL light wire according to the present invention; and
figure 6 illustrates diagrammatically a preferred embodiment of a light tube according to the present invention.

Figure 1 shows a diagrammatic cross section through a preferred embodiment of a linear EL light source according to the present invention, which is indicated in general by the reference numeral 1, and which hereinafter will also be indicated by the term "light tube". The EL light tube 1 comprises a core 10 and a transparent casing 30. The transparent casing can be made of, for example, PVC or another suitable plastic. In an embodiment which proved suitable, the casing 30 had an external diameter of approximately 15 mm and a thickness of approximately 1.5 mm. The area between the core 10 and the transparent casing 30 is indicated as annular wire accommodation area 20.

The core 10 can be solid, and can be made of a transparent plastic, for example a polymer. As will be explained in greater detail later with reference to figure 6, it is then advantageous if the core contains a photoluminescent phosphor or a mixture of photoluminescent phosphors. In addition, it can be advantageous if the core comprises colour pigments. In the illustrated example of figure 1, the core 10 comprises a number of inside feed-through current conductors 11, three in the example shown. Each feed-through current conductor 11 is surrounded by an insulating sheath 12. In a suitable embodiment, the inside feed-through current conductors 11 are made of copper wire, and the insulating sheath 12, which can be made of PVC or the like, has an external diameter of 2 mm.

An important aspect of the light tube according to the present invention is that said light tube is quite flexible and can be wound up like a cable on a reel or the like. During the unreeling, tensile stresses can then arise in the light source. In order to absorb these tensile stresses, in other words in order to prevent the electrical components of the light tube from being pulled to pieces, the core 10 preferably comprises - as shown - a pull relief 13 in the form of a wire with a high tensile strength. Said wire is preferably made of suitable plastic fibres; Teflon has been found to be a suitable material. The pull relief wire 13 is preferably situated in the centre of the core 10, with the feed-through current conductors 11 around it, the diameter of the pull relief wire 13 preferably being so small that the three feed-through current conductors 11 can touch each other.

If the core 10 is not made of a transparent material, it is advantageous for the core 10 to have an outer surface that is reflecting to at least a considerable degree. This can be achieved by giving each individual inside feed-through current conductor 11 a reflecting outer surface, or by making each insulating sheath 12 reflecting. In the example shown, the core 10 comprises a reflecting core sheath 14, which is fitted around the inside feed-through current conductors 11. The reflecting core sheath 14 can be provided by winding a strip of aluminium foil, silver foil or the like around the inside feed-through current conductors 11.

In the embodiment shown, a number of primary EL light wires 21, and also a number of outside feed-through current conductors 26, are provided in the annular wire accommodation area 20.

The primary EL light wires 21, of which there are six in the example shown, are preferably identical to one another and can in principle be any commercially available primary EL light wires that are known per se. In an embodiment found suitable, the primary EL light wires 21 are of the design illustrated in figures 3 and 4 of GB-2.273.606, with a solid copper core electrode wire 22, a layer with an EL substance 23 provided

around said core electrode wire, a double design of outer electrode 24 that is wound with a pitch of approximately 15 mm around the EL layer 23, and a transparent outer sheath 25 made of PVC, the external diameter of the transparent outer sheath 25 being approximately 2 mm.

The outside feed-through current conductors 26, of which there are three in the example shown, are each surrounded by an insulating sheath 27. In a suitable embodiment, the outside feed-through current conductors 26 are made of copper wire, and the insulating sheath 27, which can be made of PVC or the like, has an external diameter of 2 mm.

In order to achieve an advantageous optical effect, the outside feed-through current conductors 26 are preferably provided with a reflecting outer surface. It is possible for each insulating sheath 27 to be provided with a reflecting outer surface. In an embodiment found suitable, the insulating sheaths 27 were made of transparent PVC, and the outside feed-through current conductors 26 were made of tin-plated copper wire.

The combination of a feed-through current conductor and its insulating sheath will also be indicated hereinafter by the term insulated current wire. From the point of view of manufacture, it is advantageous if the outside insulated current wires are identical to the inside insulated current wires.

Although this is not critical, the external diameters of the primary EL light wires 21, on the one hand, and of the outside insulated current wires 26, 27, on the other hand, are preferably approximately equal to each other, and at the most equal to half the difference between the internal diameter of the transparent casing 30 and the (average) external diameter of the core 10. It is advantageous if the primary EL light wires 21 and the outside insulated current wires 26, 27 are accommodated with play in the annular wire accommodation area 20, but said play must not be so great that the primary EL light wires 21 and/or the outside insulated current wires 26, 27 can cross each other.

The outside insulated current wires 26, 27 and the primary EL light wires 21 can be provided exactly parallel to the

longitudinal direction of the core 10. Preferably, however, the outside insulated current wires 26, 27 and the primary EL light wires 21 are wound around the core 10 at a predetermined pitch. In an embodiment found suitable, said pitch is approximately 15 cm.

For a description of the electrical connection possibilities of the EL light tube 1 according to the present invention, reference is now made to figure 2. Two EL light tube segments, indicated by the reference numerals 1_1 and 1_2 respectively, are shown in figure 2. These EL light tube segments 1_1 and 1_2 are identical to each other and have a design such as that described above with reference to figure 1. For a good understanding of the electrical connection possibilities, the length of the EL light tube segments 1_1 and 1_2 is not important. However, in practice, EL light tube segments will be produced as units of a standard length; a standard length of, for example, 100 m is a suitable length.

In the following, the components of various EL light tube segments will be indicated by the same reference numerals as in figure 1, but provided with a subscript 1, 2 etc.

It will be clear that an EL light tube segment can have electrical connections only at its ends. In principle, the EL light tube segments are symmetrical, in the sense that they do not have any preferred direction for electric current. It is thus possible to supply an EL light tube segment with power by way of either the one end or the other end, and it is even possible to supply some of the primary EL light wires of a segment with power by way of the one end and to supply other primary EL light wires of that segment with power by way of the other end. In the following, an end of an EL light tube segment to which a voltage source is connected will be indicated by the term input end, and the other end will be indicated by the term output end. In the drawing, the input end will always be situated on the left of the segment in question, and the output end will be situated on the right of the segment in question. Likewise, the ends of the current wires and of the primary EL

light wires 21 will be indicated by the term input end and the term output end, respectively. For the sake of clarity, no individual reference numerals will be allocated here to the input and output ends.

A voltage source suitable for controlling EL light sources is indicated by the reference numeral 100 in figure 2. The voltage source 100 has a first voltage output 101, which is connected to the input ends of the six primary EL light wires $21_{1(1-6)}$ of the first EL light source segment 1_1. It is pointed out in this respect that the first voltage output 101 has, of course, two poles, for connection to the two electrodes 22_1, 24_1 of said primary EL light wires 21_1, but that detail will not always be explicitly repeated here. It is also pointed out that in this exemplary application the six primary EL light wires 21_1 of the first EL light source segment 1_1 are thus connected in parallel, because they are all connected to the same voltage output 101. Of course, it is also possible for the voltage source 100 to have six different first voltage outputs, for supplying the six different EL light sources 21_1 respectively with power. It is also possible for not all six of the EL light sources 21_1 to be connected, in other words for only some of the EL light sources 21_1 to be in operation. This last possibility can occur, for example, if the six different EL light wires 21_1 are not identical, but have different EL substances 23, so that the six different EL light wires 21_1 generate different colours of light.

In figure 2, the primary EL light wires 21 are indicated symbolically by a wavy line. A supply coupling 28 is indicated symbolically by a straight line. A supply coupling 28 is formed by the combination of an inside insulated feed-through current conductor 11 and an outside insulated feed-through current conductor 26. In the example discussed of figure 1, there are three of such pairs of current conductors, and there are therefore three supply couplings $28_{i,1}$, $28_{i,2}$ and $28_{i,3}$ in each segment 1_i.

The voltage source 100 further has a second voltage output 102, which is connected to the input end of a first supply

coupling $28_{1,1}$ of the first EL light source segment 1_1. The input ends of the primary EL light wires $21_{2(1-6)}$ of the second EL light source segment 1_2 are connected to the output end of the first supply coupling $28_{1,1}$ of the first EL light source segment 1_1. In this way, the primary EL light wires 21_2 of the second EL light source segment 1_2 are supplied with power by the second voltage output 102 of the voltage source 100.

Since in the embodiment shown each EL light source segment 1_i comprises three supply couplings $28_{i,1}$, $28_{i,2}$ and $28_{i,3}$, a total of four EL light source segments can be coupled to each other in series and supplied with power from the one voltage source 100. As shown in figure 2, the voltage source 100 therefore has a third voltage output 103, which is connected to the input end of a second supply coupling $28_{1,2}$ of the first EL light source segment 1_1, and a fourth voltage output 104, which is connected to the input end of a third supply coupling $28_{1,3}$ of the first EL light source segment 1_1. By way of a supply coupling $28_{2,1}$ of the second EL light source segment 1_2, the input ends of the primary EL light wires 21_3 of the third EL light source segment 1_3 are connected to the output end of the second supply coupling $28_{1,2}$ of the first EL light source segment 1_1, so that the primary EL light wires 21_3 of the third EL light source segment 1_3 are supplied with power by the third voltage output 103 of the voltage source 100. By way of a supply coupling 28 of the third EL light source segment 1_3 and a supply coupling 28 of the second EL light source segment 1_2, the input ends of the primary EL light wires 21_4 of the fourth EL light source segment 1_4 are connected to the output end of the third supply coupling $28_{1,3}$ of the first EL light source segment 1_1, so that the primary EL light wires 21_4 of the fourth EL light source segment 1_4 are supplied by the fourth voltage output 104 of the voltage source 100.

It will be clear to a person skilled in the art that it is possible to couple a different number N of EL light source segments 1_i (i=1, 2, ... N) to each other in series if the voltage source 100 has N voltage outputs and each segment has (N-1) supply couplings.

In the above it is described that light source segments can be connected to each other in series, the light wires of each segment being supplied by way of coupling wires in the preceding segment, in order thus to obtain a whole with a greater length than a single segment. The point of departure here is the use of standard segments of a standard length, for example 100 m, which standard length is based, inter alia, on the capabilities of a voltage source. If the voltage source has sufficient capacity to supply light source segments of greater length, the light source segments could be manufactured with greater standard length, for example 500 m. Instead of this, it is, however, possible to make use of light source segments of relatively short length, such as 100 m, a number of which, for example 5, are connected to each other in series, by always connecting the input ends of the light wires of a segment to the output ends of the light wires of the preceding segment, as a result of which the combination behaves electrically like a single segment, before connecting a segment in the manner discussed above.

Figure 2B illustrates another connection possibility for the EL light source segments according to the present invention. Only three voltage outputs 101, 102 and 103 of the voltage source 100 are used here. The first voltage output 101 is again connected to the input ends the first EL light source segment 1_1. The first voltage output 101 is also connected to the input end of the first supply coupling $28_{1,1}$. The second voltage output 102 is connected to the input end of the second supply coupling $28_{1,2}$ of the first EL light source segment 1_1, and the third voltage output 103 is connected to the input end of the third supply coupling $28_{1,3}$ of the first EL light source segment 1_1. Further, the output end of the second supply coupling $28_{i,2}$ of each EL light source segment 1_i is connected to the input ends of the six primary EL light wires $21_{(i+1)(1-6)}$ of the following EL light source segment 1_{i+1} and to the input end of the first supply coupling $28_{(i+1),1}$ of the following EL light source segment 1_{i+1}, and the output end of the third supply coupling $28_{i,3}$ of each EL light source segment 1_i is connected to the input end of the

second supply coupling $28_{(i+1),2}$ of the following EL light source segment 1_{i+1}. Further, the output end of the first supply coupling $28_{i,1}$ of each EL light source segment 1_i is connected to the output ends of the six primary EL light wires $21_{i(1-6)}$ of this EL light source segment 1_i. In this way, each light wire receives power supply both from its one end and from its other end, with the result that the maximum usable length of the light source segments has become twice as great.

Since in the embodiment shown each EL light source segment 1_i comprises three supply couplings $28_{i,1}$, $28_{i,2}$, and $28_{i,3}$, in this way a total of three EL light source segments can be connected in series to each other and supplied from the one voltage source 100. Since the maximum length of each segment has doubled, the maximum length of the light tube according to figure 2B is, however, greater than that according to figure 2.

In the embodiment described above, current wires 26, 27 are present in the wire accommodation area 20. However, this is not necessary. In the event that it is desired to supply the EL wires at their two opposite ends, as illustrated in figure 2B, it is possible to suffice with current wires in the core 10. If it is not necessary to supply power to additional wires, nor to supply power to the EL wires at their two opposite ends, the inside current wires 11, 12 and the outside current wires 26, 27 may even be dispensed with entirely. The core 10 can then, for example, be made of a transparent plastic, which is advantageously provided with photoluminescent phosphor or phosphors, as mentioned earlier.

In the wire accommodation area 20 there is then room for additional EL wires, so that a greater light output can be obtained in this way. In fact, it is possible to replace the abovementioned current wires in the wire accommodation area 20 by EL wires, but that is relatively expensive. Moreover, the light tube as a whole then becomes relatively rigid. The outside current wires in the wire accommodation area 20 are therefore preferably replaced by transparent filler wires, preferably made of a transparent polymer. The object of said filler wires is,

inter alia, to keep the EL wires at equal distances from each other. The combination of a transparent core 10 and distances kept between the EL wires by the transparent filler wires then offers the advantage that the light tube can have a greater light output, because light that is transmitted by an EL wire to the interior of the light tube passes through the core and can emerge from the light tube at the opposite side. Furthermore, the diverging lens effect of the light-transmitting filler wires produces a better diffusion of the generated light.

As will be explained in greater detail later with reference to figure 6, it then has advantages if the filler wires contain a photoluminescent phosphor or a mixture of photoluminescent phosphors. In addition, it may be advantageous if the filler wires contain colour pigments.

In the preferred embodiments discussed, the current wires and the primary EL light sources are shown as being circular. It will, however, be clear that these components may have any suitable contour. The same applies to the core 10 and the casing 30.

In the above, the light tube of figure 1 is explained using EL light wires that are known per se. However, the present invention also provides improved designs for EL light wires, and these improved EL light wires are preferably used instead of the said known wires.

In the following, a number of improvements for EL light wires according to the present invention will be explained with reference to figures 3-5.

Figure 3 shows diagrammatically a cross section of a known primary EL light wire 21, for example as known from the said known British Patent Application GB-2.273.606. As already stated, the primary EL light wire 21 has a solid copper core electrode wire 22, a layer with an EL substance 23 provided around said core electrode wire, and a wire 24 acting as outer electrode and being wound at a pitch of approximately 15 mm

around the EL layer 23. Provided around that is a transparent tubular outer casing 25, made of PVC.

This known EL light wire has a number of disadvantages.

First, the tubular outer casing 25 does not provide good protection for the EL substance 23. Owing to the fact that the outer electrode wire 24 lies on the substantially cylindrical EL layer 23, there are air-filled areas on either side of the outer electrode 24, between the EL layer 23 and the outer casing 25, into which moisture can penetrate, as indicated by reference numeral 29. In addition, the manufacture of the known EL light wire is difficult, on account of the need for placing the two wires 22 and 24 in the tube 25.

Secondly, it is a disadvantage that the EL layer 23 is surrounded by the non-transparent outer electrode 24: this outer electrode prevents the emergence of light from the part of the EL layer 23 situated under the outer electrode, and this means, on the one hand, a loss of light output and, on the other hand, an adverse effect on the homogeneity of the transmitted light.

Thirdly, it is a disadvantage that the outer electrode 24 is thinner than the core electrode wire 22, so that the quantity of electric power that can be carried by said EL wire 21 is limited to the quantity that can be carried without damage by the outer electrode wire 24.

The invention provides a solution to these drawbacks.

Figure 4A shows diagrammatically a cross section of a first embodiment of a primary EL light wire 121 improved according to the present invention. The core electrode wire 22 and the layer with an EL substance 23 provided around that can be the same as those of the known EL wire 21, and the same applies to the wire 24 acting as outer electrode. The improvement proposed by the present invention lies in the replacement of the tubular outer casing 25 by a transparent protective layer 125. This transparent protective layer 125 is manufactured by providing a suitable transparent polymer around the wire 22 by means of an extrusion process, preferably under vacuum conditions. As a result of this, the areas 29 on either side of the wire 24 acting as outer electrode are well filled up with polymer

material, with the result that good protection of the EL layer 23 is provided.

A further elaboration of this inventive idea is illustrated in figure 4B. Figure 4B shows a second embodiment of a primary EL light wire 221 improved according to the present invention. The core electrode wire 22 and the layer with an EL substance 23 provided around that can be the same as those of the known EL wire 21. A transparent conducting protective layer 225 is provided around them. This protective layer 225 is manufactured by providing a suitable transparent and conducting polymer around the wire 22 by means of an extrusion process, preferably under vacuum conditions. Owing to the fact that the protective layer 225 is itself conducting, this protective layer can act as outer electrode, so that the wire 24 can be omitted. The said areas 29 are then eliminated automatically, and the protection of the EL layer 23 is further improved.

For electrical protection, an insulating layer is also preferably provided around the conducting protective layer 225, but for the sake of simplicity this is not shown in figure 4B.

Figure 5A shows a first embodiment of a composite EL light wire 301 proposed by the present invention. The composite EL light wire 301 comprises two core electrode wires 22_1 and 22_2, an EL layer 23_1, 23_2 being provided around each core electrode wire 22_1, 22_2. The combination of a core electrode wire 22_1, 22_2 with corresponding EL layer 23_1, 23_2 can be identical to the known combination of core electrode wire 22 with EL layer 23. The two core electrode wires 22_1 and 22_2 extend next to each other, with their EL layers 23_1 and 23_2 touching each other. In the following, the combination of two core electrode wires 22_1 and 22_2 with the two EL layers 23_1 and 23_2 will be indicated as EL assembly 302.

Such a composite EL light wire 301 according to the present invention can be supplied electrically by connecting the two poles of the electricity supply to the two core electrode wires 22_1 and 22_2, respectively. The maximum transmittable electric power is now no longer limited by the relatively small diameter

of the outer electrode wire 24 of the known EL wire 21, but is determined by the diameter of the solid copper core electrode wires 22_1, 22_2, which diameter is greater than that of the said outer electrode wire 24 of the known EL wire 21, so that a greater electric power can be transmitted.

By using a greater electric power, the light output of the EL layers 23_1 and 23_2 increases, but the maximum usable length of the composite EL light wire 301 also increases. The gain achieved can be so great that in the case of use in a light tube such as, for example, the light tube of figure 1, it is no longer necessary to include copper auxiliary conductors in the core thereof (110), with the result that there is a saving of copper wire, so that such a light tube can be manufactured more cheaply. Furthermore, such a light tube acquires improved flexibility if the solid copper wires can be omitted. The core can now be made of a solid plastic such as a solid nylon-like substance which is completely transparent, and the tensile strength of which matches that of the said Teflon pull relief 13, so that said pull relief can be omitted.

The electric field to which the EL layers 23_1 and 23_2 are subjected is greatest on a line connecting the two axes of the two core electrode wires 22_1 and 22_2. The electric field strength is least in the part of the EL layer 23_1, 23_2 facing away from the corresponding other core electrode wire 22_2, 22_1, respectively. If it is desired to distribute the field lines of the electric field better over the available EL substance 23_1, 23_2, a single conducting outer wire 303 can be wound around the EL assembly 302, as illustrated in the perspective view of figure 5B. This outer wire 303 is not connected to the power source, and therefore does not serve to transmit electric power, and is thus not a limiting factor in the transmission of the electric power.

In a comparable way as described above with reference to figure 4A, the EL layers 23_1, 23_2 of the composite EL light wire 301 can also be protected by the extrusion of a protective layer 304 of transparent polymer around the EL assembly 302. Since the protective layer 304 is provided by means of extrusion, the

polymer material 304 can connect over substantially the entire periphery of the EL layers 23_1, 23_2 therewith, wherein in particular the two V-shaped areas on either side of the contact point between both EL layers 23_1, 23_2 are also filled up. A good protection of the EL layers 23_1 and 23_2 is achieved by this. This protection can be even further optimized if the application of the transparent layer 125 is carried out under vacuum conditions.

Owing to the fact that the polymer layer 304 is transparent, the light generated by the EL assembly 302 can emerge unimpeded towards all sides. Herein, it is preferable to manufacture the protective layer 304 from a conducting and transparent polymer: in that case the said outer wire 303 can in fact be dispensed with, as illustrated in figure 5C, and a better spread of the electric load over the surface of the EL assembly 302 is achieved.

The manufacture of such a composite EL light wire 301 according to the present invention can advantageously be carried out by first manufacturing two individual wires 22/23. In this way it can be ensured that each EL layer 23 has a substantially uniform thickness. The two individually manufactured wires are then laid against each other and the sheath 304 is applied.

A special advantage is offered here if the sheath 304 adheres to the EL layers 23, for example through the fact that the sheath 304 is fused with the EL layers. If the composite light wire 301 is bent, the EL layers of the two primary wires have the tendency to slide along each other, and this can cause the EL layers to wear. Such sliding along each other is counteracted if the sheath 304 is fused with the EL layers.

As a variant, a conducting polymer layer of substantially uniform thickness can first be placed around each individual wire 22/23 (not illustrated separately). There again, the two individually manufactured wires are laid against each other, and the sheath 304 is applied, and in this case it is preferred that the sheath 304 adheres to the outside layer of the "substrate", in this case these said conducting polymer layers, for example

by the fact that the sheath 304 is fused with these said conducting polymer layers. An advantage of this then is that the fusing, caused by heat during the extrusion process, will not adversely affect the EL layer.

In this case the sheath 304 need not be conducting.

Figure 6 illustrates a preferred embodiment 401 of an EL light tube according to the present invention, which preferred embodiment offers a high light output, is relatively easy to manufacture and has good resistance to moisture.

In the diagrammatic cross section of figure 6, a core of the light tube 401 is indicated by the reference numeral 410. The core is made of a transparent plastic, preferably a polymer, and may, if desired, be made of a conducting plastic. The core 410 is preferably as clear as possible, in order to cause as little light absorption loss as possible.

A number of primary EL light wires 420, six in the example shown, are disposed around the core 410. The number of primary EL light wires 420 can also be fewer or greater than six. Although standard EL light wires can in principle be used for this, it is preferred to use composite EL light wires 301 for this, more preferably the embodiment discussed with reference to figure 5C. In the following, it will be assumed that the light tube 401 comprises three composite EL light wires 301, but this number can also be greater or smaller than three; especially when the light output of the phosphors used in the light wires is regarded as inadequate, the number of composite EL light wires 301 can be greater, for example six.

Furthermore, a number of plastic filler wires 430 are disposed around the core 410. The purpose of said filler wires 430, which are made of a transparent plastic, preferably a polymer, which plastic is preferably a fire-retardant material, is, inter alia, to hold the composite EL light wires 301 in position relative to each other and relative to the core 410, and thus to ensure a mutual distance between adjacent EL light wires, through which light can pass out from the interior of the light tube 401.

In the example of figure 6 shown, two EL light wires are always placed against each other, always flanked by two filler wires placed against each other. If use is made of individual light wires, for example the wires 121 or 221 discussed above, the individual light wires can also always be flanked by at least one filler wire. However, the composite EL wires 301 of figure 5C are preferably used, although in figure 6 the sheath 304 is not shown.

In the example of figure 6 shown, two filler wires placed against each other, between two successive light wires, are always used. The number of successive filler wires 430 between successive light wires can, however, be smaller or greater than two. Said number of successive filler wires 430 is preferably greater than two, it being preferred that the diameter of the filler wires 430 is smaller than the diameter of the EL wires, because a better diffusion of the light is then achieved.

The combination of the core 410, the composite EL light wires 301 and the filler wires 430 is enclosed by an outer sheath 440. The outer sheath 440 is applied around the combination of the core 410, the composite EL light wires 301 and the filler wires 430 by means of an extrusion process, by means of which the material of the outer sheath 440 has penetrated well into the spaces between said wires 301 and 430, so that said spaces, on the one hand, are not lost spaces and, on the other hand, do not form cavities in which moisture can collect. Furthermore, the transmission of the generated light to the outside is improved.

During the extrusion process, the temperature is preferably regulated in such a way that the outside of the filler wires 430 becomes soft or even begins to flow, so that the material of the outer sheath 440 adheres well to the material of the filler wires 430, or even fuses with said material. Various advantages are offered by this. The transmission of the generated light to the outside is even further improved. The mechanical stability of the light tube increases, and the filler wires can absorb tensile strength from the outer sheath 440.

The light tube 401 can be designed for generating virtually any desired colour of light by incorporating passive pigments (colour filters) in the outer sheath 440, in which case, in order to achieve a particular colour, a person skilled in the art can make a suitable choice from pigments which are known per se.

In a preferred embodiment, the light tube 401 according to the present invention is provided with a photoluminescent phosphor. The phosphor, or a mixture of phosphors, can be processed in the plastic material of the outer sheath 440, but also in the plastic material of the core 410 and/or in the plastic material of the filler wires 430. The presence of a photoluminescent phosphor in the plastic material of one or more of the components of the light tube 401 according to the present invention, preferably in the material of the outer sheath 440, offers various advantages. First, it is possible, by a suitable choice of the photo-luminescent phosphor, to design a light tube in such a way that said light tube can radiate virtually any desired colour of light, even when standard EL light wires with a standard electro-luminescent phosphor are used. Secondly, when a photoluminescent phosphor is incorporated in the light tube 401 according to the present invention, said light tube continues to give light even if the power supply fails. This is an important aspect in those situations in which the light tube is being used as a safety marking, boundary marking or the like. In normal circumstances, the photoluminescent phosphor is continuously charged, either by daylight or by the light transmitted by the primary EL light wires or the composite EL light wires 301. Moreover, the photoluminescent phosphor amplifies the light output of the light tube 401 in the dark.

The present invention thus provides an EL light wire 221 with a core electrode wire 22; a layer with an EL substance 23 provided around said core electrode wire; and a protective layer 225 of a transparent, electrically conducting polymer, preferably containing a photoluminescent phosphor, extruded

around the combination of core electrode wire 22 and EL layer 23 under vacuum conditions and acting as outer electrode.

The present invention further provides a composite EL light wire 301 with an EL assembly 302 comprising two core electrode wires 22_1, 22_2 extending substantially parallel to each other, each provided with a layer with an EL substance 23_1, 23_2 arranged around it, and also a protective layer 304 of a transparent, electrically conducting polymer preferably containing a photoluminescent phosphor, extruded around the EL assembly 302 under vacuum conditions.

It will be clear to a person skilled in the art that the scope of the present invention is not restricted to the examples discussed above, but that various changes and modifications thereof are possible without departing from the scope of the invention as defined in the appended claims. For instance, the conducting protective layer, instead of being made of a conducting polymer, can be made of any desired conducting and transparent material, for example tin dioxide.

Further, thhe conducting core of the EL wires can be made of a conducting polymer, instead of copper.

Further, the electroluminescent phosphors and/or the photoluminescent phosphors can be replaced by luminescent polymers.

In the above, the filler wires 430 are discussed as mutually independent filler wires. However, it is also possible for a predetermined number of filler wires to be combined with each other in advance. It is also possible to replace the filler wires by a filler tape with a suitable profiling.

Claims

1. EL light tube (401), comprising:
a core (410);
a number of EL light wires (420) disposed around the core (410);
a number of plastic filler wires (430) of a transparent plastic disposed around the core (410);
and an outer sheath (440) extruded around the combination of the core (410), the EL light wires (420) and the filler wires (430).

2. EL light tube according to claim 1, wherein the EL light wires (420) are disposed at regular mutual intervals around the core (410), and wherein the filler wires (430) are disposed between adjacent EL light wires.

3. EL light tube according to claim 1 or 2, wherein the filler wires (430) are made of a transparent polymer.

4. EL light tube according to any of the preceding claims, wherein the filler wires (430) are made of a fire-retardant material.

5. EL light tube according to any of the preceding claims, wherein the outer sheath (440) is fused with the filler wires (430).

6. EL light tube according to any of the preceding claims, wherein each EL light wire (121) comprises:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
a wire (24) which acts as outer electrode and is wound around the EL layer (23) at a predetermined pitch;
and a protective layer (125) extruded around the combination of core electrode wire (22), EL layer (23) and outer electrode (24).

7. EL light tube according to any of claims 1-5, wherein each EL light wire (221) comprises:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
and an electrically conducting protective layer (225), acting as outer electrode, extruded around the combination of core electrode wire (22) and EL layer (23).

8. EL light tube (401), comprising:
a core (410);
a number of EL assemblies (302) disposed around the core (410);
a number of plastic filler wires (430) of a transparent plastic disposed around the core (410);
and an outer sheath (440) extruded around the combination of the core (410), the EL assemblies (302) and the filler wires (430);
wherein each EL assembly (302) comprises two core electrode wires (22_1, 22_2) extending substantially parallel to each other, each core electrode wire (22_1, 22_2) being provided with a layer with an EL substance (23_1, 23_2) of substantially uniform thickness arranged around said core electrode wire, and wherein the two EL layers (23_1, 23_2) preferably touch each other.

9. EL light tube according to claim 8, wherein the EL assemblies (302) are disposed at regular mutual intervals around the core (410), and wherein the filler wires (430) are disposed between adjacent EL assemblies.

10. EL light tube according to claim 8 or 9, wherein the filler wires (430) are made of a transparent polymer.

11. EL light tube according to any of claims 8-10, wherein the filler wires (430) are made of a fire-retardant material.

12. EL light tube according to any of claims 8-11, wherein the outer sheath (440) is fused with the filler wires (430).

13. EL light tube according to any of claims 8-12, wherein an electrically conducting outer wire (303) is wound around each EL assembly (302).

14. EL light tube according to any of claims 8-13, wherein an extruded protective layer (304) is provided around each EL assembly (302) and the possible outer wire (303) thereof.

15. EL light tube according to claim 14, wherein the protective layer (304) is made of an electrically conducting material.

16. EL light tube according to any of claims 1-15, wherein the outer sheath (440) contains passive pigments.

17. EL light tube according to any of claims 1-16, wherein the core (410) is made of a transparent plastic, preferably a polymer.

18. EL light tube according to claim 17, wherein the core (410) is made of a conducting plastic, preferably a conducting polymer.

19. EL light tube according to any of claims 1-18, wherein the material of the outer sheath (440) and/or the material of the core (410) and/or in the material of the filler wires (430) contains a photoluminescent phosphor or a mixture of photoluminescent phosphors.

20. EL light tube (1), comprising:

- a transparent, tubular casing (30) with an inner surface;
- a core (10) with an outer surface, which core is situated substantially centrally inside the casing (30);
- a wire accommodation area (20) defined between the outer surface of the core (10) and the inner surface of the casing (30);

- a number, preferably six, of EL light wires (21; 121; 221) provided in said wire accommodation area (20).

21. EL light tube according to claim 20, wherein each EL light wire (21) comprises:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
a wire (24), acting as outer electrode, which is wound around the EL layer (23) at a predetermined pitch;
and a transparent outer sheath (25).

22. EL light tube according to claim 20, wherein each EL light wire (121) comprises:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
a wire (24), acting as outer electrode, which is wound around the EL layer (23) at a predetermined pitch;
and a protective layer (125) extruded around the combination of core electrode wire (22), EL layer (23) and outer electrode (24).

23. EL light tube according to claim 20, wherein each EL light wire (221) comprises:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
and an electrically conducting protective layer (225), acting as outer electrode, extruded around the combination of core electrode wire (22) and EL layer (23).

24. EL light tube (1), comprising:
- a transparent, tubular casing (30) with an inner surface;
- a core (10) with an outer surface, which core is situated substantially centrally inside the casing (30);

- a wire accommodation area (20) defined between the outer surface of the core (10) and the inner surface of the casing (30);
- a number, preferably three to six, of EL assemblies (302) arranged in said wire accommodation area (20), wherein each EL assembly (302) comprises two core electrode wires (22_1, 22_2) extending substantially parallel to each other, wherein each core electrode wire (22_1, 22_2) is provided with a layer with an EL substance (23_1, 23_2) of substantially uniform thickness arranged around said core electrode wire, and wherein the two EL layers (23_1, 23_2) preferably touch each other.

25. EL light tube according to claim 24, wherein an electrically conducting outer wire (303) is wound around each EL assembly (302).

26. EL light tube according to claim 24 or 25, wherein an extruded protective layer (304) is provided around each EL assembly (302) and the possible outer wire (303) thereof.

27. EL light tube according to claim 26, wherein the protective layer (304) is made of an electrically conducting material.

28. EL light tube according to any of claims 20-27, further comprising a number of filler wires (430) of a transparent plastic disposed in said wire accommodation area (20).

29. EL light tube according to claim 28, wherein the EL light wires (420) or EL assemblies (302), respectively, are disposed at regular mutual intervals around the core (410), and wherein the filler wires (430) are disposed between adjacent EL light wires or adjacent EL assemblies, respectively.

30. EL light tube according to claim 28 or 29, wherein the filler wires (430) are made of a transparent polymer.

31. EL light tube according to any of claims 28-30, wherein the material of the filler wires (430) contains colour pigments and/or a photoluminescent phosphor or a mixture of photoluminescent phosphors.

32. EL light tube according to any of claims 20-31, further comprising a number, preferably three, of outer current wires (26, 27) provided in said wire accommodation area (20), each outer current wire comprising an outer feed-through current conductor (26) and an insulating sheath (27).

33. EL light tube according to any of claims 20-32, wherein the core (410) is solid and is made of a transparent plastic, preferably a polymer.

34. EL light tube according to claim 33, wherein the core (410) contains colour pigments and/or a photoluminescent phosphor or a mixture of photoluminescent phosphors.

35. EL light tube according to any of claims 20-32, wherein the core (10) comprises a number, preferably three, of inner insulated current wires (11, 12), each inner current wire (11, 12) comprising an inner feed-through current conductor (11) and an insulating sheath (12).

37. EL light tube according to claim 36, wherein the core (10) is designed to be reflecting, preferably by the fact that the core (10) comprises a reflecting core sheath (14), which is provided around the inner insulated current wires (11, 12) and is preferably provided by winding a strip of aluminium foil, silver foil or the like around the inner insulated current wires (11, 12).

38. EL light tube according to any of claims 20-37,wherein the core (10) comprises a pull relief (13), preferably made of suitable plastic fibres such as Teflon.

39. EL light tube (121), comprising:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
a wire (24), acting as outer electrode, which is wound around the EL layer (23) at a predetermined pitch;
and a protective layer (125) extruded around the combination of core electrode wire (22), EL layer (23) and outer electrode (24), which protective layer (125) is made of a transparent polymer and contains a photoluminescent phosphor or a mixture of photoluminescent phosphors.

40. EL light tube (221), comprising:
a core electrode wire (22);
a layer with an EL substance (23) provided around said core electrode wire;
and an electrically conducting protective layer (225), acting as outer electrode, which is extruded around the combination of core electrode wire (22) and EL layer (23), which protective layer (225) is made of a transparent polymer and contains a photoluminescent phosphor or a mixture of photoluminescent phosphors.

41. Composite EL light wire (301), comprising an EL assembly (302), which comprises two core electrode wires (22_1, 22_2) extending substantially parallel to each other, wherein each core electrode wire is provided with a layer with an EL substance (23_1, 23_2) of substantially uniform thickness arranged around said core electrode wire, and wherein the two EL layers (23_1, 23_2) touch each other.

42. Composite EL light wire according to claim 41, wherein an electrically conducting outer wire (303) is wound around the EL assembly (302).

43. Composite EL light wire according to claims 41 or 42, wherein an extruded protective sheath (304) is provided around the EL assembly (302) and the possible outer wire (303).

44. Composite EL light wire according to claim 43, wherein the protective sheath (304) is made of an electrically conducting material.

45. EL light wire according to claim 43 or 44, wherein the extruded protective sheath is provided under vacuum conditions.

46. EL light wire according to any of claims 43-45, wherein the extruded protective layer is made of a transparent polymer.

47. EL light wire according to claim 46, wherein the polymer material of the extruded protective layer contains a photoluminescent phosphor or a mixture of photoluminescent phosphors.

48. EL light wire according to any of claims 39-47, wherein the core electrode wires (22_1, 22_2) are made of a conducting polymer.

49. EL light wire according to any of claims 43-48, wherein the extruded protective sheath (304) is fused with the two EL layers (23_1, 23_2).

50. Composite EL light wire, comprising an EL assembly (302), which comprises two core electrode wires (22_1, 22_2) extending substantially parallel to each other, wherein each core electrode wire is provided with a layer with an EL substance (23_1, 23_2) of substantially uniform thickness arranged around said core electrode wire, and also with a conducting polymer layer of substantially uniform thickness arranged around that, wherein the two conducting polymer layers touch each other.

51. Composite EL light wire according to claim 50, wherein an electrically conducting outer wire (303) is wound around the EL assembly (302).

52. Composite EL light wire according to claims 50 or 51, wherein an extruded protective sheath (304) is provided around the EL assembly (302) and the possible outer wire (303).

53. Composite EL light wire according to claim 52, wherein the protective sheath (304) is made of an electrically conducting material.

54. EL light wire according to claim 52 or 53, wherein the extruded protective sheath is provided under vacuum conditions.

55. EL light wire according to any of claims 52-54, wherein the extruded protective sheath is made of a transparent polymer.

56. EL light wire according to claim 55, wherein the polymer material of the extruded protective layer contains a photoluminescent phosphor or a mixture of photoluminescent phosphors.

57. EL light wire according to any of claims 50-56, wherein the core electrode wires (22_1, 22_2) are made of a conducting polymer.

58. EL light wire according to any of claims 52-57, wherein the extruded protective sheath (304) is fused with the two said conducting polymer layers.

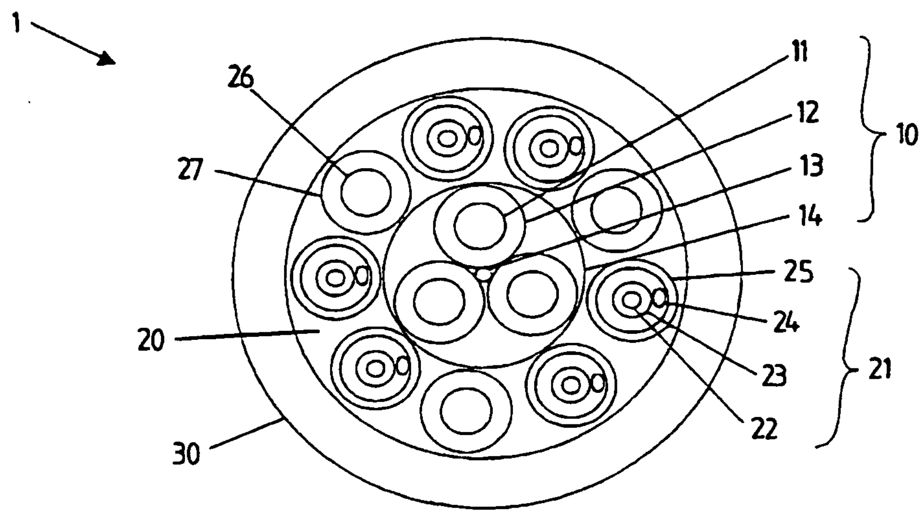


FIG.1

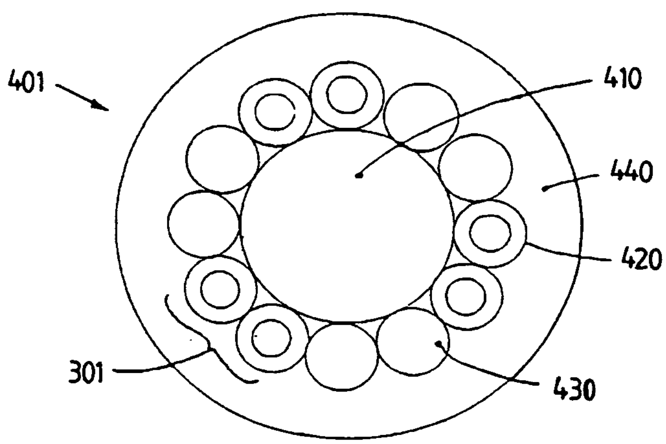
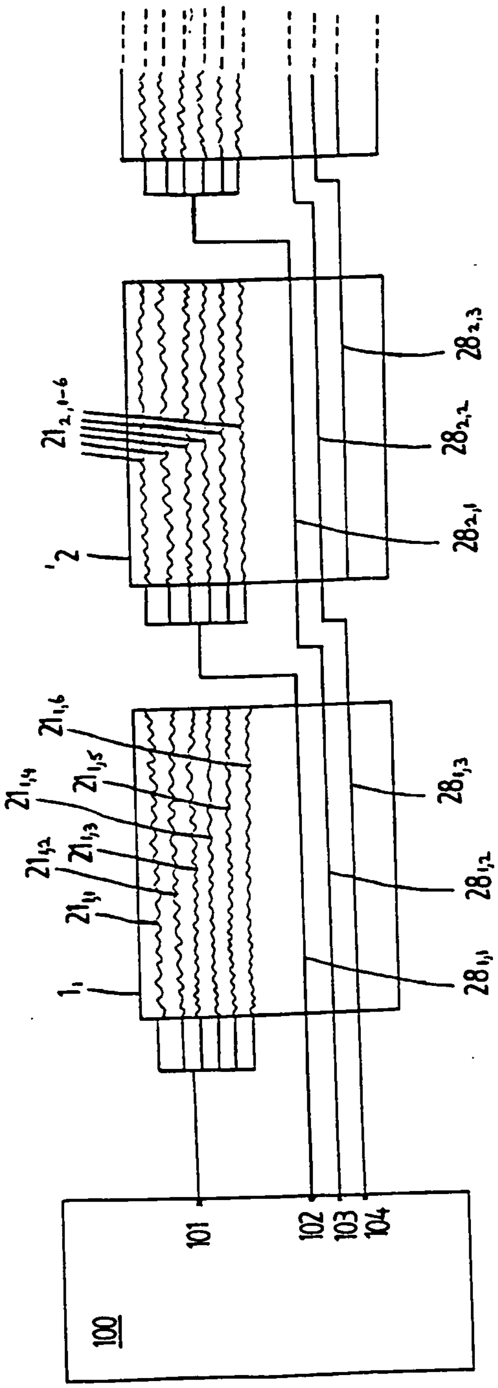


FIG. 6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21₁,₆
21₂,₁₋₆
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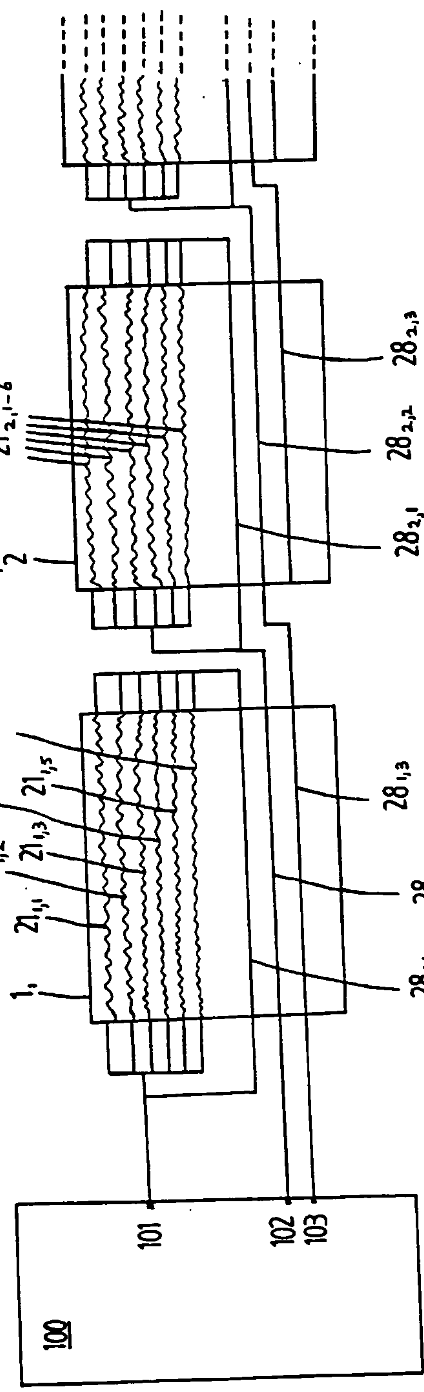
FIG. 2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$28_{2,1}$
$28_{2,2}$
$28_{2,3}$
100
101
102
103

FIG. 2B

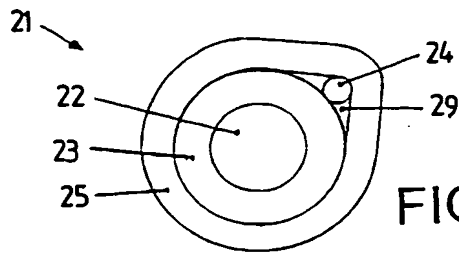

FIG. 3

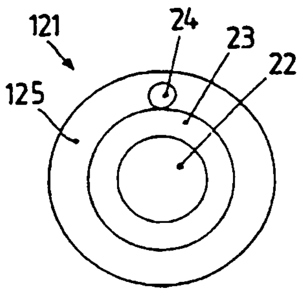

FIG. 4A

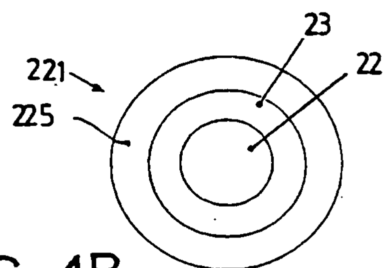

FIG. 4B

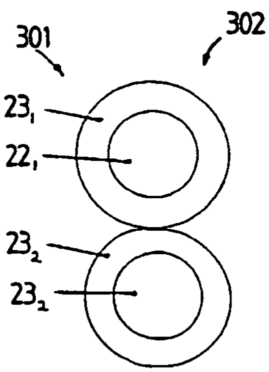

FIG. 5A

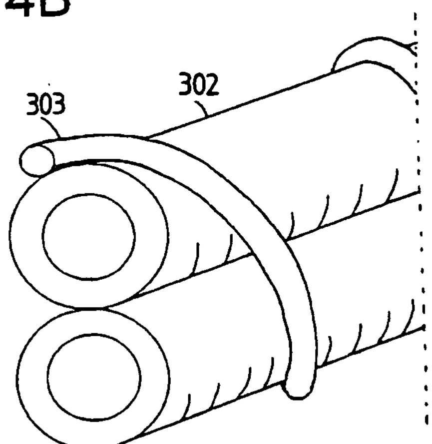

FIG. 5B

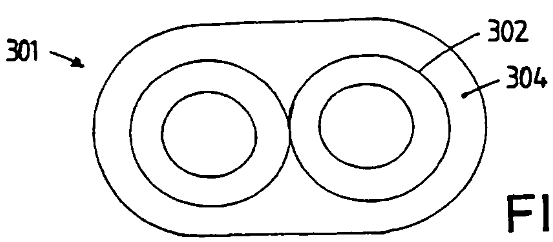

FIG. 5C

INTERNATIONAL SEARCH REPORT

Intern. ...al Application No
PCT/NL 00/00895

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/00 H05B33/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 15939 A (ELAM ELECTROLUMINESCENT IND LT) 1 May 1997 (1997-05-01) the whole document ---	1-6,8,9, 11-14, 17, 24-26, 33,39, 41-43, 46, 50-52,55
E	DE 198 25 435 A (MAGNA REFLEX HOLDING GMBH) 9 December 1999 (1999-12-09) column 3, line 26-52; claims 1-13; figure 4 --- -/--	6,7,39, 40

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 April 2001	17/04/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Drouot-Onillon, M-C

2

INTERNATIONAL SEARCH REPORT

Intern   .nal Application No
PCT/NL 00/00895

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 819 973 A (HOSFORD A) 25 June 1974 (1974-06-25) the whole document	6,39,41, 43, 45-47, 50,52, 54-56
X	DE 37 42 412 A (WEINEM HANNELORE) 29 June 1989 (1989-06-29) the whole document	6
X	WO 97 24015 A (ADD VISION INC) 3 July 1997 (1997-07-03) the whole document	6
A	EP 0 838 975 A (ELAM ELECTROLUMINESCENT IND LT) 29 April 1998 (1998-04-29) cited in the application the whole document	1-19, 39-58

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 00/00895

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